

# Glossary of Polymer Terminology

## Sources:

### IUPAC:

*"Glossary of Basic Terms in Polymer Science", Commission on Macromolecular Nomenclature, Macromolecular Division, International Union of Pure and Applied Chemistry, draft: May 13, 1991.*

### IUPAC:

*"Definition of Terms Relating to Individual Macromolecules, Their Assemblies, and Dilute Solutions", Commission on Macromolecular Nomenclature, Macromolecular Division, International Union of Pure and Applied Chemistry, Pure and Appl. Chem., 61 (2), 211-241, 1989.*

### IUPAC:

*"Stereochemical Definitions and Notations Relating to Polymers", Commission on Macromolecular Nomenclature, Macromolecular Division, International Union of Pure and Applied Chemistry, Pure and Appl. Chem., 53, 733-752, 1981.*

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## Future Plans:

- designate entries IUPAC91, IUPAC89 and IUPAC81.
- include all terms defined
- add equations

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## a:

### alternating copolymer:

a copolymer consisting of macromolecules comprising two species of monomeric units in alternating sequence. (IUPAC)

### alternating copolymerization:

a copolymerization in which an alternating copolymer is formed. (IUPAC)

### anionic polymerization:

an ionic polymerization in which the kinetic-chain carriers are anions. (IUPAC)

### atactic macromolecule:

a regular macromolecule in which the configurational (base) units are not all identical. (IUPAC)

atactic polymer:

a substance composed of atactic macromolecules. (IUPAC)

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## **b:**

bead-rod model:

A model simulating the hydrodynamic properties of a chain macromolecule consisting of a sequence of beads, each of which offers hydrodynamic resistance to the flow of the surrounding medium and is connected to the next bead by a rigid rod which does not. The mutual orientation of the rods is random. (IUPAC)

bead-spring model:

A model simulating the hydrodynamic properties of a chain macromolecule consisting of a sequence of beads, each of which offers hydrodynamic resistance to the flow of the surrounding medium and is connected to the next bead by a spring which does not contribute to the frictional interaction but which is responsible for the elastic and deformational properties of the chain. The mutual orientation of the springs is random. (IUPAC)

block:

a portion of a macromolecule, comprising many constitutional units, that has at least one feature which is not present in the adjacent portions. (IUPAC)

block copolymer:

a copolymer that is a block polymer. In a block copolymer, adjacent blocks are constitutionally different, i.e., each of these blocks comprises constitutional units derived from different characteristic species of monomer or with different composition or sequence distribution of constitutional units. (IUPAC)

block macromolecule:

a macromolecule which is composed of blocks in linear sequence. (IUPAC)

block polymer:

a substance composed of block macromolecules. (IUPAC)

branch:

an oligomeric or polymeric offshoot from a branched chain. (IUPAC)

branch point:

a point on a chain at which a branch is attached. (IUPAC)

branched chain:

a chain with at least one branch point intermediate between the boundary units (i.e. the end-groups or other branch points). (IUPAC)

branched polymer:

a polymer, the molecules of which are branched chains. (IUPAC)

cationic polymerization:

an ionic polymerization in which the kinetic-chain carriers are cations. (IUPAC)

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## C:

chain:

the whole part of part of a macromolecule (or oligomer molecule or block) comprising a sequence of constitutional units between two boundary constitutional units, each of which may be either an end-group or a branch point. Except in linear single-strand macromolecules, the definition of the chain may be somewhat arbitrary. A cyclic macromolecule has no end groups but may nevertheless be regarded as chain. Where appropriate, definitions relating to "macromolecule" may also be applied to "chain". (IUPAC)

chain polymerization:

a chain reaction in which the growth of a polymer chain proceeds exclusively by reaction(s) between monomer(s) and reactive site(s) on the polymer chain such that the reactive site(s) are regenerated on the same polymer chain by the end of each growth step. A chain polymerization consists of initiation and propagation reactions, and may also include termination and chain transfer reactions. The adjective "chain" in "chain polymerization" denotes "chain reaction". In a chain polymerization, the average degree of polymerization remains constant with monomer conversion (e.g., in steady-state, radical polymerizations) or may increase with monomer conversion (e.g., in the formation of living polymers). (IUPAC)

chain transfer:

a chemical reaction, usually occurring during chain polymerizations, in which the activity of the kinetic-chain carrier is transferred from the growing macromolecule or oligomer molecule to another molecule or another part of the same molecule. Chain transfer to another part of the same molecule is often termed backbiting. (IUPAC)

comb macromolecule:

a macromolecule comprising a main chain from which long chains emanate at approximately regular intervals. (IUPAC)

comb polymer:

a substance composed of comb macromolecules. (IUPAC)

compositional heterogeneity:

the variation in elemental composition from molecule to molecule usually found in copolymers. (IUPAC)

configurational base unit:

a constitutional repeating unit in a regular macromolecule (or oligomer or block), the configuration of which is defined at least at one site of stereoisomerism in the main chain. (IUPAC)

**configurational repeating unit:**

the smallest set of successive configurational base units that prescribes configurational repetition at one or more sites of stereoisomerism in the main chain of a regular macromolecule (or oligomer or block). (IUPAC)

**configurational sequence:**

the whole or part of a chain comprising one or more species of configurational units in defined sequence. Note: configurational sequences comprising two configurational units are termed diads, those comprising three configurational units triads, and so on. In order of increasing sequence lengths they are called tetrads, pentads, hexads, heptads, octads, nonads, decads, etc. (IUPAC)

**configurational unit:**

a constitutional unit having at least one site of stereoisomerism. (IUPAC)

**constitutional heterogeneity:**

the variation in constitution from molecule to molecule in polymers with molecules uniform with respect to elemental composition. (IUPAC)

**constitutional sequence:**

the whole or part of a chain comprising one or more species of constitutional units in defined sequence. Note: constitutional sequences comprising two constitutional units are termed diads, those comprising three constitutional units triads, and so on. In order of increasing sequence lengths they are called tetrads, pentads, hexads, heptads, octads, nonads, decads, etc. (IUPAC)

**constitutional repeating unit:**

the smallest constitutional unit, the repetition of which constitutes a regular macromolecule (or oligomer molecule or block). (IUPAC)

**constitutional unit:**

an atom or group of atoms in a macromolecule or oligomer molecule, comprising a part of the chain together with its pendant atoms or groups of atoms, if any. (IUPAC)

**co-oligomer:**

an oligomer derived from more than one species of monomer. (IUPAC)

**co-oligomerization:**

oligomerization in which a co-oligomer is formed. (IUPAC)

**copolymer:**

a polymer derived from more than one species of monomer. Note: copolymers that are obtained by copolymerization of two monomer species are sometimes termed bipolymers, those obtained from three monomers terpolymers, those obtained from four monomers quaterpolymers, etc. (IUPAC)

**copolymerization:**

polymerization in which a copolymer is formed. (IUPAC)

**crosslink:**

a constitutional unit connecting two parts of a macromolecule that were earlier separate molecules. Note: a network may be thought to consist of many "primary chains" that are interconnected by a number of crosslinks. In the vast majority of cases, the crosslink is a covalent bond but the term is also used to describe sites of weaker chemical interactions, portions of crystallites, and even physical entanglements. (IUPAC)

**cross-over concentration:**

The concentration at which the sum of the volumes of the domains occupied by the solute molecules or particles in solution is approximately equal to the total volume of that solution. (IUPAC)

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**d:****degree of polymerization:**

the number of monomeric units in a macromolecule or oligomer molecule. (IUPAC)

**depolarization of scatter light:**

The phenomenon, due primarily to the anisotropy of the polarizability of the scattering medium, resulting from the fact that the electric vectors of the incident and scattered beams are not coplanar and that, therefore, light scattered from a vertically (horizontally) polarized incident beam contains a horizontal (vertical) component. (IUPAC)

**dilute solution:**

A solution in which the sum of the volumes of the domains occupied by the solute molecules or particles is substantially less than the total volume of the solution. (IUPAC)

**double-strand chain:**

ladder chain: a chain that comprises constitutional units always joined to each other through four atoms, two on each constitutional unit. (IUPAC)

**double-strand copolymer:**

ladder copolymer: a copolymer, the macromolecules of which are double-strand chains. (IUPAC)

**double-strand polymer:**

ladder polymer: a polymer, the macromolecules of which are double-strand chains. (IUPAC)

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**e:****end-group:**

a constitutional unit with only one attachment to a chain. (IUPAC)

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**f:****Flory-Huggins theory:**

A thermodynamic theory of polymer solutions, first formulated independently by Flory and by Huggins, in which the thermodynamic quantities of the solution are derived from a simple concept of combinational entropy of mixing and a reduced Gibbs-energy parameter, the 'X parameter'. The X parameter is a numerical parameter employed in the Flory-Huggins theory, which accounts in the main for the contribution of the non-combinational entropy of mixing and for the enthalpy of mixing. (IUPAC)

**freely-draining:**

An adjective referring to a chain macromolecule the segments of which produce such small frictional effects when moving in a medium such that the hydrodynamic field in the vicinity of a given segment is not affected by the presence of other segments. Thus, the solvent can flow virtually undisturbed through the domain occupied by a freely-draining macromolecule. degree of polymerization: the number of monomeric units in a macromolecule or oligomer molecule. (IUPAC)

**frictional coefficient:**

A tensor correlating the frictional force  $F$ , opposing the motion of a particle in a viscous fluid, and the velocity  $u$  of this particle to the fluid. (IUPAC)

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**g:****gel-permeation chromatography:**

(recommended abbreviation: GPC ) A separation technique in which separation mainly according to the hydrodynamic volume of the molecules or particles takes place in porous non-adsorbing material with pores of approximately the same size as the effective dimensions in solution of the molecules to be separated. (IUPAC)

**graft copolymer:**

a copolymer that is a graft polymer. In a graft copolymer, adjacent blocks are constitutionally different, i.e., each of these blocks comprises constitutional units derived from different characteristic species of monomer or with different composition or sequence distribution of constitutional units. (IUPAC)

**graft macromolecule:**

a macromolecule with one or more species of block connected to the main chain as side chains, these side chains having constitutional or configurational features that differ from those in the main chain. (IUPAC)

**graft polymer:**

a substance composed of graft macromolecules. (IUPAC)

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**h:****homopolymer:**

a polymer derived from one species of (real, implicit, or hypothetical) monomer. Note: many polymers are made by mutual reaction of complementary monomers. These monomers can readily be visualized as reacting to give an "implicit monomer", the homopolymerization of which would give the actual product, which can then be regarded as a homopolymer. Example: poly(ethylene terephthalate). Some polymers are obtained by modification of other polymers such that the structure of the macromolecules that constitute the resulting polymer can be thought of as having been formed by homopolymerization of a "hypothetical monomer". These polymers can be regarded as homopolymers. Example: poly(vinyl alcohol). (IUPAC)

**homopolymerization:**

polymerization in which a homopolymer is formed. (IUPAC)

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**i:****inherent viscosity/logarithmic viscosity number:**

The ratio of the natural logarithm of the relative viscosity to the mass concentration of the polymer. (IUPAC)

**intrinsic viscosity/limiting viscosity number:**

The limiting value of the reduced viscosity or the inherent viscosity at infinite dilution of the polymer. (IUPAC)

**ionic copolymerization:**

a copolymerization which is an ionic polymerization. (IUPAC)

**ionic polymerization:**

a chain polymerization in which the kinetic-chain carriers are ions. Usually, the growing chain ends are ions. (IUPAC)

**ionomer molecule:**

a polyelectrolyte in which a small but significant proportion of the constitutional units carry charges. (IUPAC)

**irregular macromolecule:**

a macromolecule in which the constitutional units are not all identical. (IUPAC)

**irregular polymer:**

a substance composed of irregular macromolecules. (IUPAC)

**isotactic macromolecule:**

a macromolecule comprising only one species of configurational base unit (having chiral or prochiral atoms in the main chain) in a single arrangement with respect to its adjacent

constitutional units. Note: in an isotactic macromolecule, the configurational repeating unit is identical with the configurational base unit. (IUPAC)

isotactic polymer:

a substance composed of isotactic macromolecules. (IUPAC)

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## **I:**

ladder chain:

a chain that comprises constitutional units always joined to each other through four atoms, two on each constitutional unit. (IUPAC)

linear chain:

a chain with no branch points intermediate between the boundary units (i.e. the end-groups or other branch points). (IUPAC)

linear copolymer: a copolymer, the macromolecules of which are linear chains. (IUPAC)

linear polymer: a polymer, the macromolecules of which are linear chains. (IUPAC)

living copolymerization:

a copolymerization which is a living polymerization. (IUPAC)

living polymerization:

a chain polymerization in which the concentration of kinetic-chain carriers, under the appropriate conditions for synthesis, remains constant for a period many times longer than the duration of the synthetic procedure. Often, the absence of chain transfer is implied in the term "living polymerization". (IUPAC)

long chain:

a chain of high relative molecular mass. (IUPAC)

long-chain branch:

a polymeric offshoot from a branched chain. (IUPAC)

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## **m:**

macromolecule:

a molecule of high relative molecular mass, the structure of which essentially comprises the multiple repetition of a number of constitutional units. (IUPAC)

macromonomer:

a monomer which is a polymer of an oligomer. (IUPAC)



macromonomeric unit / macromer:

the largest constitutional unit contributed by a single macromonomer molecule to the structure of a macromolecule. (IUPAC)

macrocycle:

a cyclic macromolecule or a macromolecular cyclic portion of a molecule. (IUPAC)

main chain / backbone:

that chain to which all other chains (long or short or both) may be regarded as being pendant; where two or more chains could equally well be considered to be the main chain, that one is selected which leads to the simplest geometrical representation of the molecule. (IUPAC)

monomer:

a substance, each of the molecules of which can, on polymerization, contribute one or more constitutional units in the structure of the macromolecule. (IUPAC)

monomeric unit / mer:

The largest constitutional unit contributed by a single monomer molecule to the structure of a macromolecule or oligomer molecule. (IUPAC)

multi-strand chain:

a chain that comprises units always joined to each other through more than four atoms, more than two on each constitutional unit. (IUPAC)

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**n:**

network:

a macromolecule in which each constitutional unit is connected to each other constitutional unit and to the macroscopic phase boundary by many permanent paths through the structure, their number increasing with the average number of intervening bonds; these paths must on the average be coextensive with the macromolecule. Usually, and in all systems that exhibit rubber elasticity, the number of distinct paths is very high, but, in most cases, some constitutional units exist which are connected by a single path only. Sometimes, a structure without any multiple path has also been called a network. (IUPAC)

non-draining:

An adjective describing a chain macromolecule that behaves in a hydrodynamic field as though the solvent within the domain of the macromolecule were virtually immobilized with respect to the macromolecule. (IUPAC)

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**o:**

oligomer:

a substance composed of oligomer molecules. (IUPAC)

oligomer molecule:

a molecule of intermediate relative molecular mass, the structure of which essentially comprises a small plurality of constitutional units. (IUPAC)

oligomerization:

the process of converting a monomer or a mixture of monomers into an oligomer. (IUPAC)

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## p:

pendent group:

side group: an offshoot, neither oligomeric nor polymeric, from a chain. (IUPAC)

periodic copolymer:

a copolymer consisting of macromolecules comprising more than two species of monomeric units in regular sequence. (IUPAC)

periodic copolymerization:

a copolymerization in which a periodic copolymer is formed. (IUPAC)

polyaddition:

a polymerization in which the growth of a polymer chain proceeds by addition reactions between molecules of all degrees of polymerization, not accompanied by the formation of low-molar-mass by-product(s). (IUPAC)

polycondensation:

a polymerization in which the growth of a polymer chain proceeds by condensation reactions between molecules of all degrees of polymerization accompanied by the formation of low-molar-mass by-products(s). The growth steps are expressed by  $P_x + P_y \rightarrow P_{x+y} + L$  {x} element of {1, 2, ...  $\infty$ }; {y} element of {1, 2, ...  $\infty$ } where  $P_x$  and  $P_y$  denote chains of degree of polymerization x and y, respectively, and L a low-molar-mass by-product. In a polycondensation where the total amounts of the monomers are present from the beginning of the polymerization, the average degree of polymerization increases with conversation of reactive groups. (IUPAC)

polyelectrolyte molecule:

a macromolecule which in an ionising solvent may dissociate to give ions. (IUPAC)

polymer:

a substance composed of macromolecules. (IUPAC)

polymer-solvent interaction:

The sum of the effects of all intermolecular interactions between polymer and solvent molecules in solution that are reflected in the Gibbs and Helmholtz energies of mixing. (IUPAC)

**polymerization:**

the process of converting a monomer or a mixture of monomers into a polymer.  
(IUPAC)

**pseudo-ooligomer:**

an irregular oligomers, the molecules of which are derived from one species of monomer but for which one finds it convenient to use co-oligomer terms. (IUPAC)

**pseudo-copolymer:**

an irregular polymer, the molecules of which are derived from one species of monomer but for which one finds it convenient to use copolymer terms. Where appropriate, adjectives specifying the types of "copolymer" may be applied to "pseudo-copolymer". The term statistical pseudo-copolymer, for instance, may be used to describe an irregular polymer in the molecules of which the sequential distribution of configurational units obeys known statistical laws. (IUPAC)

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**q:****quasi-single-strand chain:**

a chain that comprises constitutional units joined to each other through one single atom on only one of the units. Quasi-single-strand chains are not single-strand chains, but they can be named in the same manner. (IUPAC)

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**r:****radical copolymerization:**

a copolymerization which is a radical polymerization. (IUPAC)

**random copolymer:**

a copolymer consisting of macromolecules in which the probability of finding a given monomeric unit at any given site in the chain is independent of the nature of the adjacent units. Note: in a random copolymer, the sequence distribution of monomeric units follows Bernoullian statistics. (IUPAC)

**random copolymerization:**

a copolymerization in which an alternating copolymer is formed. (IUPAC)

**reduced viscosity/viscosity number:**

The ratio of the relative viscosity increment to the mass concentration of the polymer.  
(IUPAC)

**regular macromolecule:**

a macromolecule in which the constitutional units are all identical with respect to both constitution and orientation. (IUPAC)

regular oligomer molecule:

an oligomer molecule in which the constitutional units are all identical with respect to both constitution and orientation. (IUPAC)

regular polymer:

a substance composed of regular macromolecules. (IUPAC)

relative viscosity/viscosity ratio:

The ratio of the viscosity of the solution to the viscosity of the solvent. (IUPAC)

relative viscosity increment:

The ratio of the difference between the viscosities of solution and solvent to the viscosity of the solvent. (IUPAC)

ring-opening copolymerization:

a copolymerization which is a ring-opening polymerization for at least one monomer. (IUPAC)

ring-opening polymerization:

a polymerization in which a cyclic monomer yields a monomeric unit which is acyclic or contains fewer cycles than the monomer. If the monomer is polycyclic, opening of one ring is sufficient to classify the reaction as ring-opening polymerization. (IUPAC)

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## S:

short chain:

a chain of low relative molecular mass. (IUPAC)

short-chain branch:

an oligomeric offshoot from a branched chain. (IUPAC)

single-strand chain:

a chain that comprises units always joined to each other through one single atom on only one of the units. (IUPAC)

spiro chain:

a chain that comprises constitutional units, joined so as to form an uninterrupted sequence of rings through single common atoms between adjacent rings. (IUPAC)

star macromolecule:

a macromolecule containing a constitutional unit from which more than two chains (arms) emanate. A star macromolecule with  $n$  linear chains (arms) attached to the central unit is termed an  $n$ -star, e.g., five-star. (IUPAC)

star polymer:

a substance composed of star macromolecules. (IUPAC)

**statistical copolymer:**

a copolymer consisting of macromolecules in which the sequential distribution of the monomeric units obeys known statistical laws. An example for a statistical copolymer is one consisting of macromolecules in which the sequential distribution of monomeric units follows Markovian statistics. (IUPAC)

**statistical copolymerization:**

a copolymerization in which a statistical copolymer is formed. (IUPAC)

**stereoblock macromolecule:**

a block macromolecule composed of stereoregular, and possibly in addition non-stereoregular, blocks. (IUPAC)

**stereoblock polymer:**

a substance composed of stereoblock macromolecules. (IUPAC)

**stereoregular macromolecule:**

a regular macromolecule comprising only one species of stereorepeating unit. (IUPAC)

**stereoregular polymer:**

a substance composed of stereoregular macromolecules. (IUPAC)

**stereorepeating unit:**

a configurational repeating unit having defined configuration at all sites of stereoisomerism in the main chain of a regular macromolecule (or oligomer molecule or block). (IUPAC)

**syndiotactic macromolecule:**

a macromolecule comprising alternating enantiomeric configurational base units. Note: in a syndiotactic macromolecule, the configurational repeating unit consists of two configurational base units that are enantiomeric. (IUPAC)

**syndiotactic polymer:**

a substance composed of syndiotactic macromolecules. (IUPAC)

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**t:****tactic macromolecule:**

a regular macromolecule in which the configurational (repeating) units are all identical. (IUPAC)

**tactic polymer:**

a substance composed of tactic macromolecules. (IUPAC)

**tacticity:**

the orderliness of the succession of configurational repeating units in the main chain of a regular macromolecule (or oligomer or block). (IUPAC)

telomer:

a substance composed of macromolecules or oligomer molecules having few, usually terminal, reactive functional groups enabling, under appropriate conditions, the formation of larger macromolecules. (IUPAC)

telomerization:

a polymerization in which a telomer is formed. (IUPAC)

theta state:

The state of a polymer solution for which the second virial coefficient is zero. (IUPAC)

theta temperature:

The temperature at which a solution is in the theta state. (IUPAC)

turbidity:

The apparent absorbance of the incident radiation due to scattering (IUPAC)

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